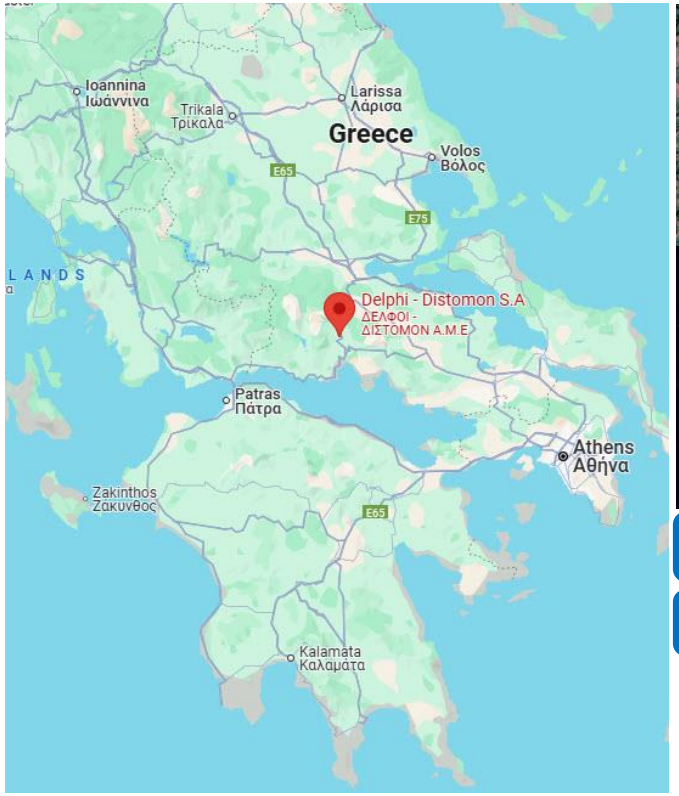
Delphi

Underground

Mining Site



Overview **Location**

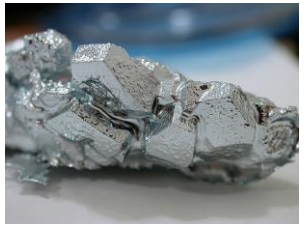
VE **VE Map**

Disclaimer

CRM_Alumina

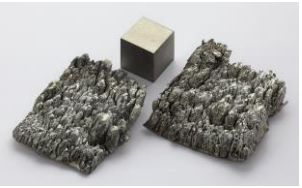
CRM_Aluminum

CRM_Bauxite



CRM_Galium

CRM_Strontium



CRM Scandium

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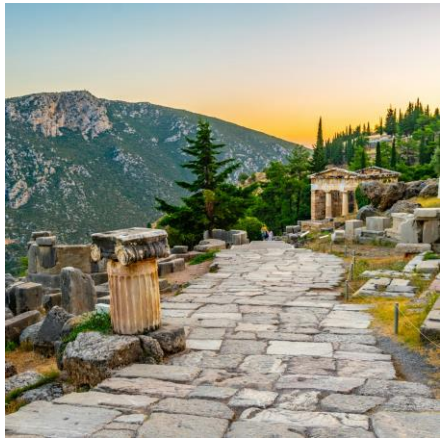
Overview

Exploitation of Locris Bauxite Deposit Ore in Delphi-Distomon

Metlen SA Mining Company changed its franchise name to “European Bauxites”. Most of the Bauxite Mining Activities implemented by Metlen SA Mining Company are Underground. The Multi-Metallic Bauxite Ore Deposit contains different types of metals. Recently, it was detected that the Locris Diasporic Bauxite Deposit Ore, except for Bauxite/Aluminum, contains Critical Raw Materials (CRMs) such as Strontium, Scandium, and Galium.
Metlen SA Mining Company in Delphi-Distomo significantly produces Bauxite, and Aluminum (with an annual production capacity of over 190 ktons of aluminum and 860 ktons of alumina).

- History
- Future Targets of Metlen SA
- Exploitation Method
- Geotechnical Engineering
- Criticality of CRMs
- Industrial Apps of CRMs
- Machinery Equipment
- Geological Characteristics of Ore

Historic Sightseeing in Delphi

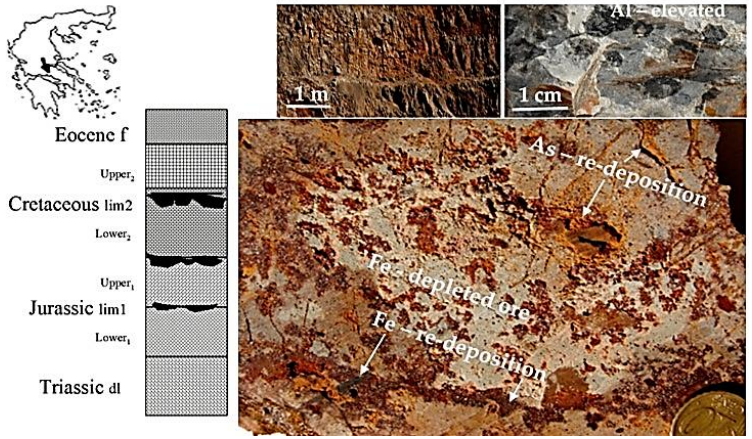



- The Stadium of Delphi lies on the highest spot of the Archaeological Site of Delphi. It overlooks the sanctuary of Apollo and has a view to the Delphic landscape. It was built either within the second half of the 4th century B.C. or even after the Galatian attacks. Its measured 178 meters in length and knew several refurbishment phases. The Stadium of Delphi is the best preserved ancient stadium in Greece.
- Temple of Apollo in Delphi, known as Apollonion, was a major part of the Panhellenic religious sanctuary located in Central Greece at Delphi. The temple and sanctuary at large were dedicated to one of the major Greek deities, Apollo, the god of archery, music, light, prophecy, the arts, and healing. There have been several temples built at Delphi throughout the history of the site, though the visible ruins seen in modernity are those of the temple built in the 4th century B.C.E. before its destruction under the orders of Theodosius I in 390 C.E.
- During antiquity, the temple was home to the famous Greek prophetess the Pythia, or the Oracle of Delphi, making the Temple of Apollo and the sanctuary at Delphi a major Panhellenic religious site as early as the 8th century B.C.E., and a place of great importance at many different periods of ancient Greek history. References to Delphi, the sanctuary, the temple, and the prophecies of the Pythia are made throughout ancient Greek mythology and historical accounts from the periods of its use.

Description of Underground Karstic-Diasporic Bauxite Mining Ore

Geological Characteristics of Ore

The limestone rockmass in Parnassus-Ghiona is highlighted by an important rate of karstification of small surfaces and large-scale dissolution features: lapiez, micro karsts, karsts
(Marilou de Vals et al., 2020)



(Maria Economou-Eliopoulos, Christos Kanelopoulos, 2023)

Mineralogical Composition of Ore

Diaspore (a-AlO(OH)) 20-50%

Bohemite (Al-OH) 10-30%

Hematite (Fe_2O_3) 20-25%

Calcite ($CaCO_3$) 1-5%

Kaolinite ($Al_2Si_2O_5(OH)_4$) 1-5%

Quartz (SiO_2) 1-2%

Anatase (TiO_2) 0.5-2%

Exploitation Method

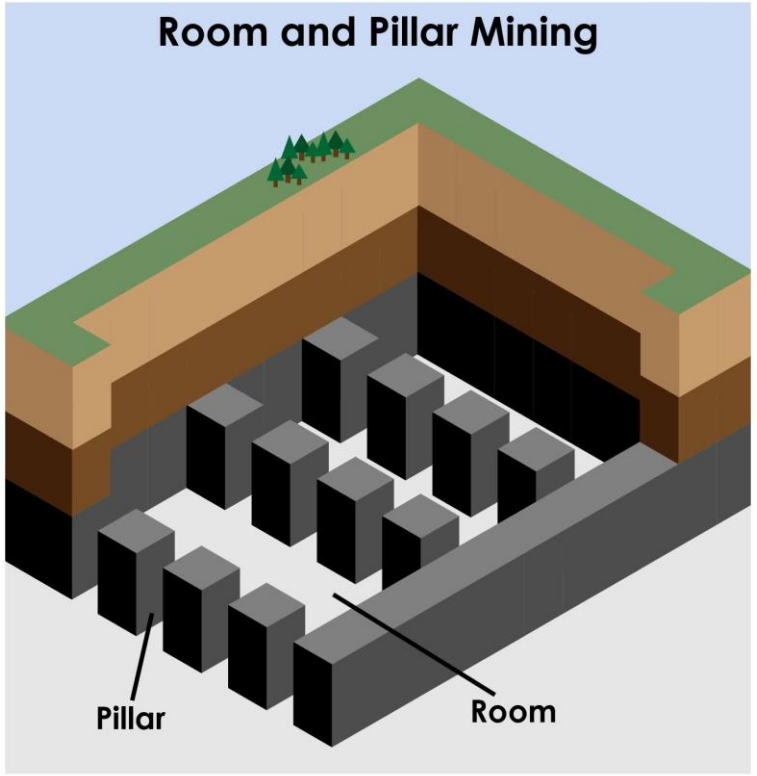
Open Stopes - Room and Pillar Mining

The Open-Stope exploitation method requires natural support, using healthy rock's compressive strength and cohesion to maintain the geotechnical stability of the space created from the excavation works.

Implementing this exploitation method aims to horizontally or moderately slope the stratified ore deposits of small or large thickness located at a small to medium depth with a resistant roof.

When the bauxite ore deposit's thickness ranges from 0 to 10m, the sloping inclination must be lower than 30°. Unless this happens, Room and Pillar combined with dry rock filling is the exploitation method that must be implemented.

So, in this case (which is the most common actual condition in Greek underground mining), two benching layers are arranged one over the other, while scrapers and excavators create pillars to ensure the project's geotechnical stability.



Source: OSMRE on X

Geotechnical Engineering

Geotechnical Characteristics of Rockmass

Young's Modulus is a fundamental mechanical property that describes the stiffness of a rock. It is symbolized with **"E"**.
E=9-14 GPa in Delphi Distomon Rockmass

Poisson's Ratio is a dimensionless material property that describes how a material deforms in the lateral direction when it is stretched or compressed longitudinally.

Poisson's Ratio= $\frac{\sigma_2}{\sigma_1} = \frac{\varepsilon_2}{\varepsilon_1} = \frac{\frac{\sigma_2}{E}}{\frac{\sigma_1}{E}}$,

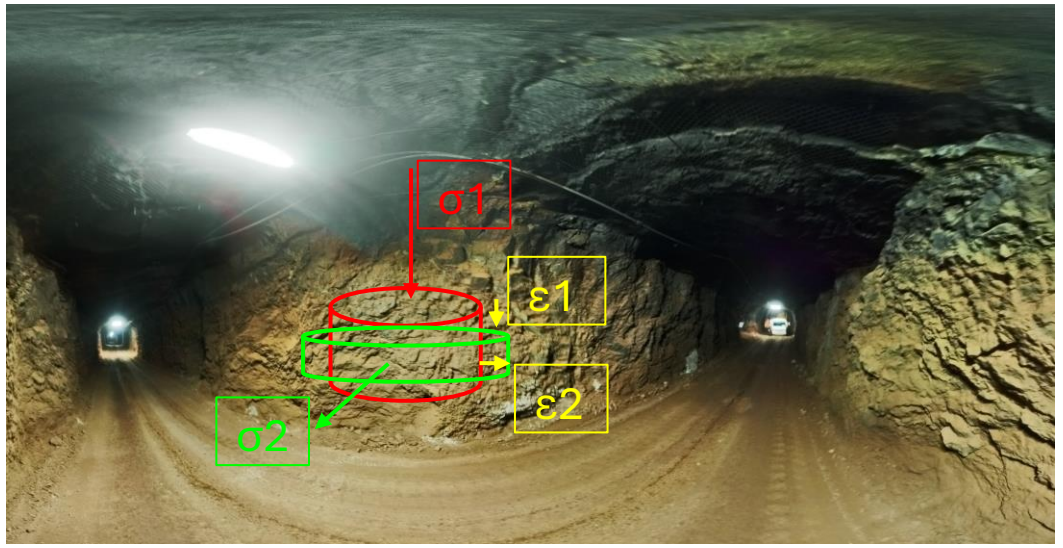
$\boldsymbol{\varepsilon_2}$=strain in the direction perpendicular to applied stress,
$\boldsymbol{\varepsilon_1}$= strain in the direction of applied stress, $\boldsymbol{\sigma_2}$=lateral stress,
$\boldsymbol{\sigma_1}$=uniaxial stress.
Poisson's Ratio of the Delphi Rockmass equals 0.25

Unit Weight of the Dephi Rockmass_26.5 κN/m³
[Rock Density multiplied with g(m/s²)]

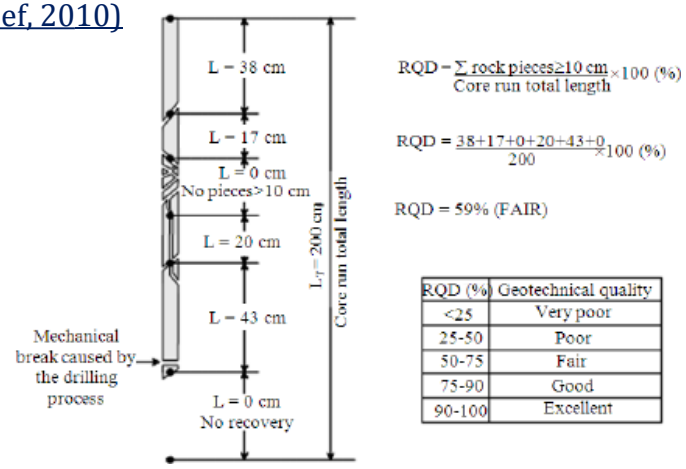
Rock Quality Designation (RQD) is an empirical index that expresses the quality of the rock based on the condition of the core samples obtained from drillings.

RQD=[$\frac{\sum Length\ of\ Core\ Sample\ Pieces > 10cm\ length * 100}{Total\ Length\ of\ Core\ (cm)}$],

Delphi Rockmass RQD equals 50-75%



(Assim Mohammed Lateef, 2010)



RQD (%)	Geotechnical quality
<25	Very poor
25-50	Poor
50-75	Fair
75-90	Good
90-100	Excellent

Exploitation Method

Machinery Equipment

Wheeling Scraper Type 1

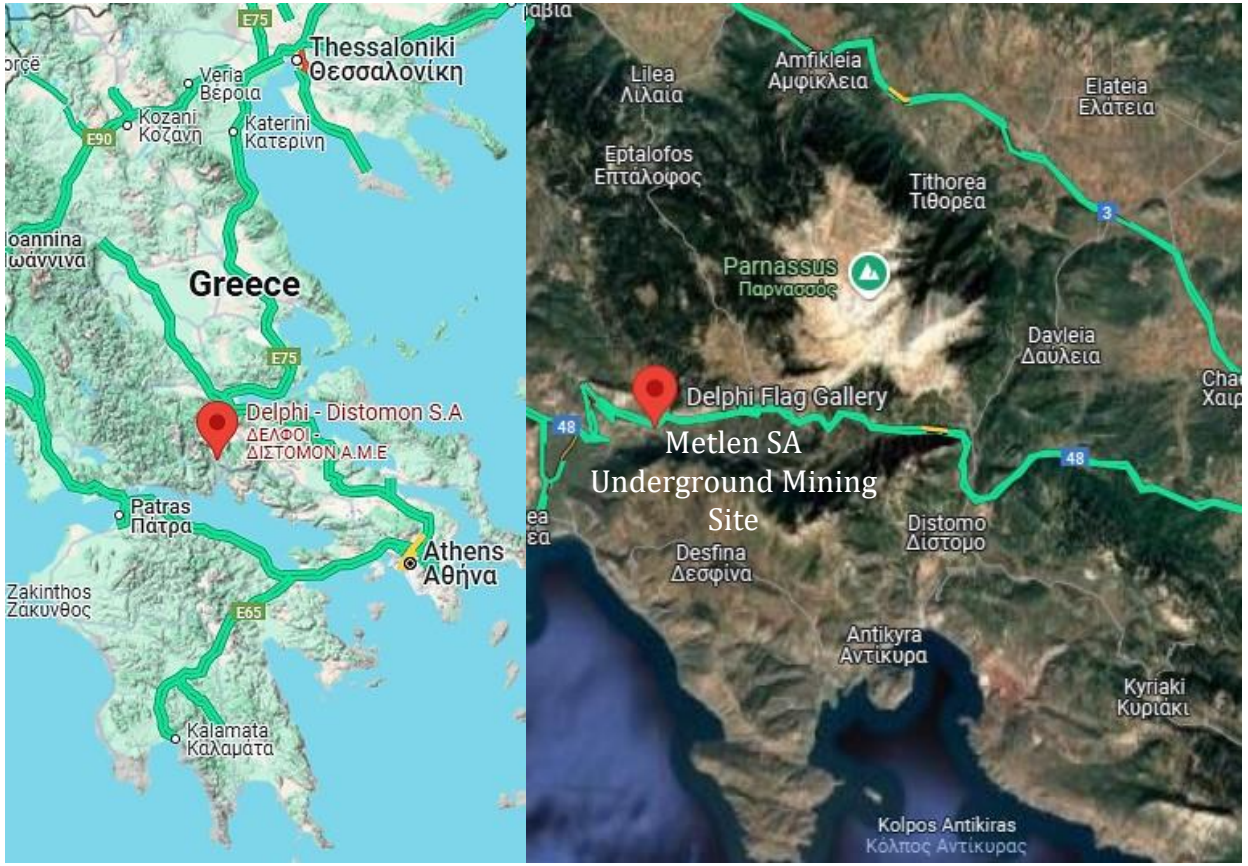
Crawler Scraper Type 2

Loading Truck

Scraper machines are separated into wheeling scrapers (type 1) and crawler scrapers (type 2). Depending on the geotechnical stability of the ground soil, each type is used. For instance, when the compaction of the ground soil is high (low porosity, higher geotechnical stability), the wheeling scraper is permitted. Otherwise, the crawler scraper is used. The role of the scraper primarily focuses on the sterile removal. Continuously, scrapers collect the beneficial mining ore from the actual mining extraction holes and load it onto the trucks.

Loading trucks are used to transfer the beneficial mining ore from the geotechnically unsafe primary mining extraction holes to the underground structural square to preliminarily dispose of it.
In the second phase, trucks transfer the beneficial mining ore from the current disposal site to the purification unit for further beneficiation to separate metals from ore and each other. The maximum capacity of a truck is approximately 30 tons of ore.

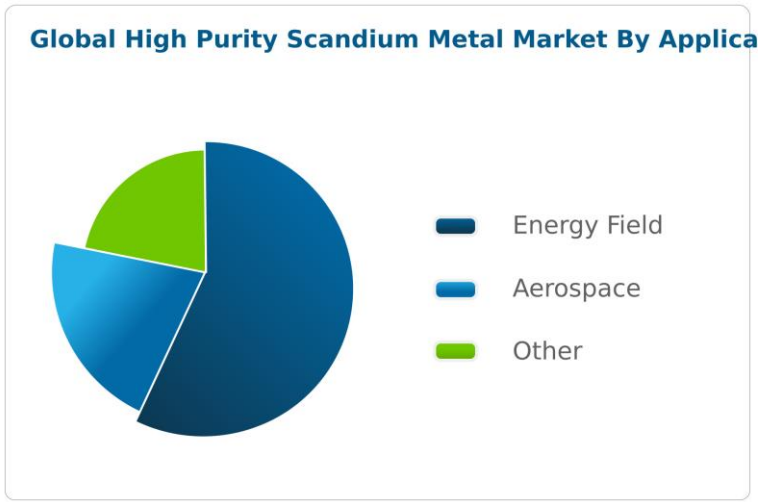
Map of the Virtual Excursion

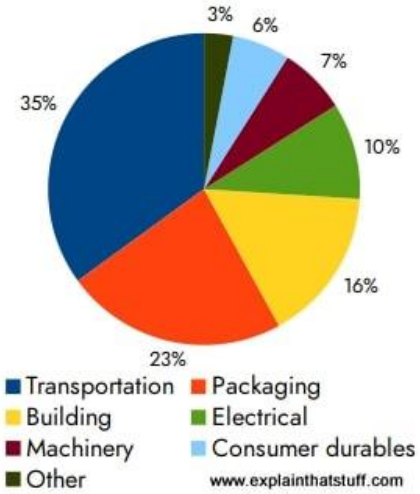


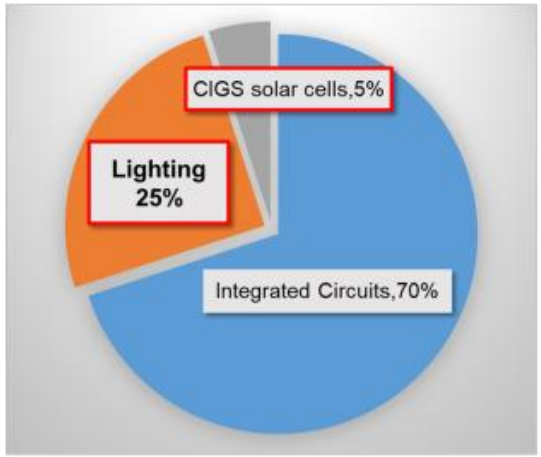
Metlen SA Underground Mining Site

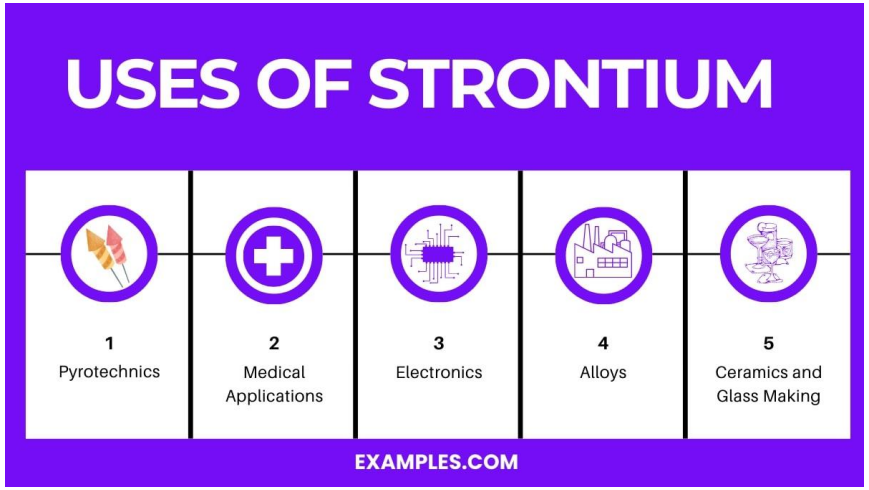
Latitude:38°41’86.2”N_Longtitude:22°76’18.6”E

Industrial Applications of CRMs









CRMs - Aluminum/Bauxite (Al), Scandium (Sc), Strontium (Sr), Galium (Ga)
Click to see Criticality Assessment of Al, Sc, Sr, Ga

Supply Risk: Risk Grade of the material resources
Economic Importance: Grade of the material's price value to the market
Criticality: Grade of material's impact on the Market

CRM	Supply Risk SR	Economic Importance EI	Criticality CR
Aluminum/Bauxite (Al)	**2**	**2.8**	**5.6**
Ranges for SR, EI, CR	**0-5**	**0-9**	**0-45**
Impact on SR, EI, CR (%) (Numerical Value of the CRM) ÷ (Maximum Threshold)	$(SR)_{CRM} \div (SR)_{Max}$ **40%**	$(EI)_{CRM} \div (EI)_{Max}$ **31.1%**	$(CR)_{CRM} \div (CR)_{Max}$ **12.4%**

CRM	Supply Risk SR	Economic Importance EI	Criticality CR
Scandium (Sc)	**2.5**	**3.8**	**9.5**
Ranges for SR, EI, CR	**0-5**	**0-9**	**0-45**
Impact on SR, EI, CR (%) (Numerical Value of the CRM) ÷ (Maximum Threshold)	$(SR)_{CRM} \div (SR)_{Max}$ **50%**	$(EI)_{CRM} \div (EI)_{Max}$ **42.2%**	$(CR)_{CRM} \div (CR)_{Max}$ **21.1%**

CRM	Supply Risk SR	Economic Importance EI	Criticality CR
Strontium (Sr)	**2.7**	**6.5**	**17.55**
Ranges for SR, EI, CR	**0-5**	**0-9**	**0-45**
Impact on SR, EI, CR (%) (Numerical Value of the CRM) ÷ (Maximum Threshold)	$(SR)_{CRM} \div (SR)_{Max}$ **54%**	$(EI)_{CRM} \div (EI)_{Max}$ **72.2%**	$(CR)_{CRM} \div (CR)_{Max}$ **39%**

CRM	Supply Risk SR	Economic Importance EI	Criticality CR
Galium (Ga)	**4**	**3.9**	**15.6**
Ranges for SR, EI, CR	**0-5**	**0-9**	**0-45**
Impact on SR, EI, CR (%) (Numerical Value of the CRM) ÷ (Maximum Threshold)	$(SR)_{CRM} \div (SR)_{Max}$ **80%**	$(EI)_{CRM} \div (EI)_{Max}$ **43.3%**	$(CR)_{CRM} \div (CR)_{Max}$ **34.6%**

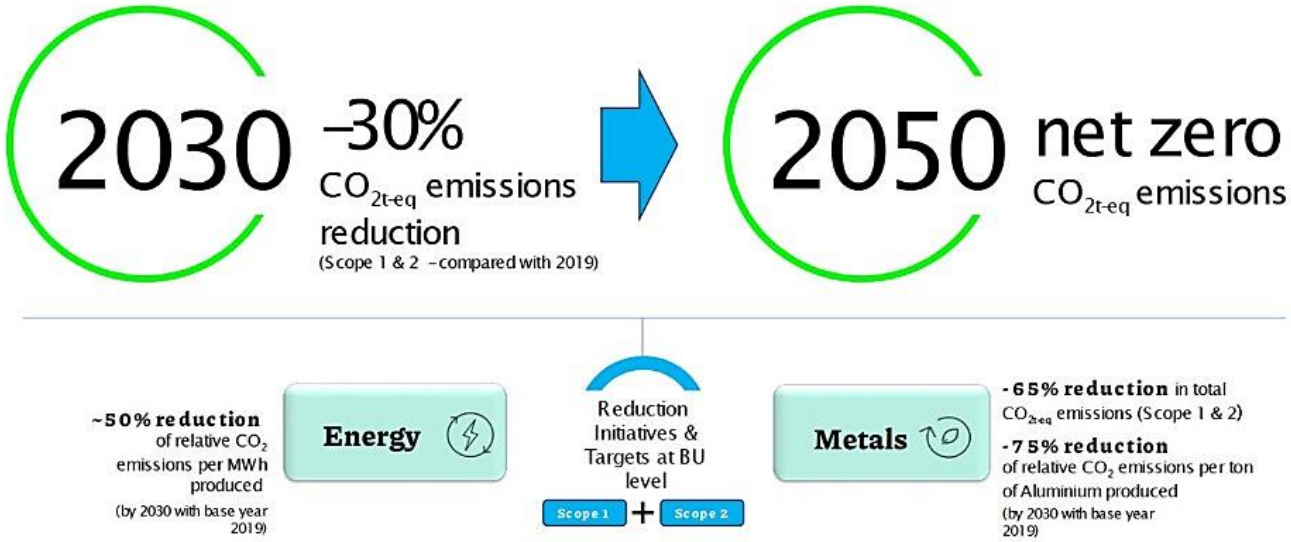
Criticality Matrix

Criticality Matrix		Supply Risk (SR)				
		1	2	3	4	5
(CR)=(EI)*(SR)						
Economic Importance (EI)	1	1	2	3	4	5 **(Al=5.6)**
	2	2	4	6	8	10
	3	3	6	9 **(Sc=9.5)**	12	15**(Ga=15.6)**
	4	4	8	12	16	20
	5	5 **(Al=5.6)**	10	15 **(Ga=15.6)**	20	25
	6	6	12	**(Sr=17.5)**18	24	30
	7	7	14	21	28	35
	8	8	16	24	32	40
	9	9 **(Sc=9.5)**	**(Sr=17.5)**18	27	36	45

- The **Criticality Matrix** displays a quantitative assessment of the Criticality grade for each examined raw material, based on the information contained in the European Study on CRMs, as shown below on this slide.
- The **Supply Risk (SR)** and **Economic Importance (EI)** refer to variable parameters that depends on the entire resources of raw materials and their configured price values according to their demand, respectively. i.e. the SR of a raw material could fluctuate within a period. Therefore, depending on the global resources data and industrial needs, the corresponding Study for CRMs could be updated, including the existing SR and EI indices for raw materials.
- The **Criticality (CR)** is configured by the multiplication of EI and SR grades. The CR index shows the criticality grade of each examined raw material.

Source: European Commission: Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, Grohol, M. and Veeh, C., *Study on the critical raw materials for the EU 2023 – Final report*, Publications Office of the European Union, 2023, **https://data.europa.eu/doi/10.2873/725585**

Future Targets in Terms of Sustainable Development



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